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(54) SOLID PROPELLANT DUAL PHASE ROCKET MOTOR

ZWEIPHASIGER FESTSTOFFRAKETENMOTOR

MOTEUR DE FUSEE A POUDRE A DOUBLE PHASE

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(56) References cited:

US-A- 2 956 401	US-A- 2 988 877
US-A- 3 286 472	US-A- 3 442 084
US-A- 3 564 845	US-A- 4 911 795
US-A- 4 956 971	US-A- 4 999 997

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to rockets and other self-propelled missiles and projectiles, and more specifically, to solid propellant rocket motors for such devices which are capable of providing multiple propulsive impulses to the vehicle in which they are installed.

2. Description of the Related Art

[0002] Motors for rockets, other types of propelled missiles and the like generally are of two types. The first, the liquid propellant motor, has a tank containing a liquid fuel such as liquid hydrogen or ammonia, and a tank containing a liquid oxidizer such as liquid oxygen, nitric acid or fluorine. The two liquids are mixed together in a combustion chamber in a specific proportion and at flow rates designed to cause the liquid to spontaneously combust. The combustion products are expelled from the rocket's exhaust nozzle, thereby providing a thrusting force to propel the rocket. Liquid propellant motors are useful for their ability to be precisely controlled; stopped and restarted; and checked out, fired and calibrated before actual use. Liquid propellant motors also are advantageous in that they provide a wide range of specific impulse ratings, i.e., the amount of thrust per unit mass of fuel burned per unit time; and a relatively long burn time.

[0003] The other major type of rocket motor is the solid propellant motor. In solid propellant systems, the rocket is propelled by a solid fuel charge or "grain" that initially is ignited by an electric or pyrotechnic igniting device. As the grain burns, it generates exhaust gases and other combustion products which are expelled through a nozzle at the end of the rocket. The combustion products are expelled from the rocket's exhaust nozzle, thereby providing a thrusting force to propel the rocket. The advantages of the solid propellant motor are its relatively simple structural design and its ease of use.

[0004] In many applications, it is desirable to use a solid propellant motor that can provide two separate and distinct propulsive impulses, i.e., a dual pulse motor. For example, the first pulse in a dual pulse motor could be used to fire a missile towards its target. When the missile is near the target, the second pulse could be fired to accelerate the missile, increase its force on impact with the target, and enhance the damage imparted to the target.

[0005] Several types of dual pulse motors have been developed. For example, U.S. Patent 4,936,092 to Andrew discloses a system in which grains for the different pulses may be contained in separate, detachable stages. When the grain for one pulse has been entirely consumed, its stage may be jettisoned and a new stage ignited. This arrangement, however, entails the duplication of relatively complicated mechanical parts, the coordination of operations therebetween, and additional weight and manufacturing considerations.

[0006] Also, as shown in U.S. Patent 3,122,884 to Grover et al., the grains may be contained in separate combustion chambers within a single stage, where the chambers have separate nozzles or share a common nozzle. Since this scheme still entails some duplication of parts, the propellant load that can be accommodated in the motor is necessarily limited and the cost and weight of the motor are increased. Also, the multiple nozzle configuration limits the size of each nozzle, thereby decreasing the available specific impulse available from the motor.

[0007] An alternative to these designs is shown in US Patent 3,908,364 to LeFebvre et al. and US Patent 4,085,584 to Jones et al. In these systems, the grains for each pulse may be accommodated in a single combustion chamber. To prevent the second grain from igniting once combustion has begun in the first grain, the grains are separated by a thin thermal insulation membrane at their interface. This membrane protects the second grain from inadvertent ignition while the first grain is burning. Once the first grain is spent, a separate igniter initiates combustion of the second grain to begin the second pulse, thereby destroying the membrane and permitting combustion products to exit from the nozzle.

[0008] US-A-2988877 discloses a solid propellent rocket motor and solid propellant charge having a novel geometry and a relatively high volumetric density.

[0009] While the above-described prior art systems serve their purpose, they require specialized ignition systems to accommodate the unique combustion characteristics of dual pulse motors. Also, the specialized ignition characteristics of dual pulse motors are fraught with unique problems such as tolerance stack-up and the difficulty of conducting reliable inspections and assemblies.

SUMMARY OF THE INVENTION

[0010] It is an object of this invention to provide a solid propellant dual pulse motor that can use standard solid propellant motor ignition train components such as through-bulkhead-initiators (TBI's), explosive transfer assemblies (ETA's) and safe-and-arms (S&A's).

[0011] It is a further object of the present invention to provide a solid propellant dual pulse motor that which is relatively easy to inspect and assemble.

[0012] It is yet another object of this invention to provide a solid propellant dual pulse motor that is substantially free from tolerance stack-up considerations and the like.

[0013] The above objects are achieved by providing a solid propellant dual pulse rocket motor that has a pressure vessel containing two pulse grains separated

by a barrier insulator. An igniter assembly disposed at a fore end of the pressure vessel selectively ignites a first pulse grain from a central channel within the grain. The igniter assembly also ignites a second pulse grain by ejecting hot combustion gases onto the fore end of the grain. Using such an ignition arrangement, a dual pulse rocket motor may be constructed using standard off-the-shelf ignition components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other objects and advantages of this invention will become apparent and more readily appreciated from the following description of the presently preferred exemplary embodiments, taken in conjunction with the accompanying drawings, of which:

FIGURE 1 is a cross-sectional diagram of a case assembly according to the present invention;
FIGURE 2 is a cross-sectional diagram of a solid propellant two pulse rocket motor according to the present invention;
FIGURE 3 is an enlarged cross-sectional diagram of a dual pulse igniter assembly according to the present invention;
FIGURE 4 is a cross-sectional diagram of a casting assembly for forming a Phase 2 grain according to the present invention; and
FIGURE 5 is a cross-sectional diagram of a casting assembly for forming a Phase 1 grain according to the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

[0015] The foundation of the present invention is the motor case assembly 10 shown in FIGURE 1. The motor case assembly 10 has a pressure vessel 12 disposed within a skirt 14. Preferably, the pressure vessel 12 has a 31.09cm (12.24 inch) maximum outer diameter and is made from a filament-wound graphite-epoxy resin composition.

[0016] The skirt 14 preferably has a 31.09cm (12.24 inch) diameter and is made from a filament-wound graphite-epoxy resin composition. Also, to alleviate any differential strains between the pressure vessel 12 and the skirt 14, it is advantageous to provide adhesive shear plies at the interface between these two components.

[0017] It should be noted that FIGURE 1 and all other Figures are cross-sectional longitudinal views of the present invention and that, although not shown, the invention and parts contained therein generally have a circular cross-section when viewed axially.

[0018] The fore end of the skirt 14 has a fore end ring 16 attached thereto, and the aft end of the skirt has an aft end ring 18 attached thereto. The fore end ring 16 provides for transfer of thrust loads and for mating to motor processing tooling, while the aft end ring 18 supports two nozzle actuators 40 (shown in FIGURE 2) and also mates to motor processing tooling. Preferably, the fore ring 16 and aft ring 18 are made from an aluminum alloy and are bonded and riveted to the skirt 14; however, other equivalent suitable materials and bonding techniques will be readily apparent to those skilled in the art.

[0019] The pressure vessel 12 has a fore polar boss 20 and an aft polar boss 22 at fore and aft ends, respectively, along its longitudinal axis. The fore polar boss 20 provides for mating and support of the motor igniter assembly 36 (shown in FIGURE 2) as described in more detail below, and the aft polar boss 22 mates with the nozzle assembly 38 (also shown in FIGURE 2) to support blowout loads. Preferably, the fore polar boss 20 and the aft polar boss 22 each are made from a titanium alloy or other compound having good high temperature characteristics (such as steel or aluminum) as will be apparent to those skilled in the art.

[0020] The pressure vessel 12 has a Pulse 1 grain 24 disposed in an aft portion of the interior of the pressure vessel 12 and a Pulse 2 grain 26 disposed in a fore portion thereof. Preferably, the Pulse 1 grain 24 is made from about 19.95 kg (44 lb.) of an aluminum powder-fueled, hydroxyl-terminated polybutadiene (HTPB) binder compo ition, and the Pulse 2 grain 26 is made from about 9.98 kg (22 lb.) of a similar composition having a higher burn rate. In a preferred embodiment, the Pulse 2 grain 26 has about a 68% higher burn rate than the Pulse 1 grain 24.

[0021] A fore insulator 28 is disposed between the pressure vessel 12 and the Pulse 2 grain 26 to provide erosion and thermal protection for the pressure vessel 12 and the Pulse 2 grain 26 while Pulse 1 is burning and during the interpulse delay. Additionally, the Pulse 2 grain 26 has a grain support 30 (preferably made from a foam material) centrally disposed at its fore end. Also, a barrier insulator 32 is disposed between the Pulse 1 grain 24 and the Pulse 2 grain 26 to provide similar protection to the aft end of the Pulse 2 grain 26, and an aft insulator 33 is disposed between the aft end of the Pulse 1 grain 24 and the aft end of the pressure vessel 12 for similar reasons. Preferably, the fore insulator 28, the barrier insulator 32 and the aft insulator 33 are made from Kevlar-filled ethylene propylene diene monomer (EPDM) material and include stress-relief boots to provide propellant bondline stress relief during cold-temperature storage and operation.

[0022] The Pulse 1 and 2 grains 24, 26 and the fore and barrier insulators 28, 32 cooperatively define a central ignition cavity 34 and, as shown in FIGURE 2, a motor igniter assembly 36 is bolted to the fore polar boss 20 at a fore end of the ignition cavity 34. In addition to showing the placement of the motor igniter assembly 36 in the pressure vessel 12, this Figure also shows the flexseal thrust vector control (TVC) nozzle 38 and one of its associated actuators 40.

[0023] As shown in FIGURE 3, the motor igniter as-

sembly 36 includes an igniter closure 42 and an igniter case 44 projecting therefrom. The igniter closure 42 fits into the fore polar boss 20 and preferably is made of a titanium alloy. The igniter case 44 has three Pulse 1 igniter grains 46, 48, disposed therein. The grains 48 preferably are made from a case-bonded propellant, and the grain 46 preferably is a case-bonded booster propellant. The grains 46, 48 are separated from ignition pellets 50 (preferably $BKNO_3$ pellets) which are separated from the grain 46 by a steel screen 52. When the ignition pellets 50 are ignited by, for example, two squibs or TBIs, they ignite the grains 46, 48, thereby consuming the igniter case 46.

[0024] Preferably, the igniter case 46 is made from aluminum or an aluminum alloy; however, any other equivalent composition that is readily consumed during ignition, e.g., magnesium or steel, can be used, as will be apparent to those skilled in the art.

[0025] When in place, the igniter closure 42 cooperates with the fore polar boss 20 to define a toroidal chamber 54 containing the Pulse 2 igniter grain 56. One or more nozzle ports 58 which allow ignition gases from the Pulse 2 igniter grain 56 to pass from the toroidal chamber 54 to the interior of the pressure chamber 12. Preferably, the nozzle ports 58 are made from short lengths of silica-phenolic material.

[0026] More specifically, when the Pulse 2 grain 56 is ignited by, for example, a squib or TBI, hot gases pass from the toroidal chamber 54 through the nozzle ports 58 and impinge upon the grain support 30 to melt it. In this process, the gases ignite the Pulse 2 propellant grain 28 to rupture the barrier insulator 32 and start the motor's second pulse.

[0027] Preferably, the motor igniter assembly includes one or more Pulse 1 pressure ports 60 and one or more Pulse 2 pressure ports 62 through which the pressures generated during the ignition process may be measured.

[0028] Although a few preferred embodiments of the invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles of the invention, the scope of which is defined in the appended claims.

Claims

1. A solid propellant dual phase motor (10) comprising:

   (a) a pressure vessel (12) having an aft opening for release of propellant material therefrom, characterised in that said motor comprises:

   (b) a first pulse grain (24) disposed in an aft portion of the pressure vessel;
   (c) a second pulse grain (26) disposed in a fore portion of the pressure vessel; and
   (d) igniter means (36) disposed in the fore portion of the pressure vessel for selectively igniting the first pulse grain (24) and the second pulse grain (26), the igniter means comprising a first pulse igniter disposed proximate the first pulse grain (24) and a second pulse igniter disposed proximate the second pulse grain (26), the second pulse igniter comprising an igniter closure (42) having torodial surfaces disposed therein which define an igniter chamber (54) and second ignition grain means (56) for igniting the second pulse grain(26), the igniter closure (42) comprising at least one nozzle port (58) providing a path from the igniter chamber (54) to the second pulse grain (26).

2. A motor as claimed in claim 1, in which the first pulse igniter comprises a casing, and first ignition grain means for igniting the first pulse grain and for burning the casing.

3. A motor as claimed in claim 2, in which the first ignition grain means comprises at least one of (a) at least one primary first igniter grain, and a booster first igniter grain; and (b) at least one igniter grain, at least one igniter pellet, and a screen separating the ignition pellet and the igniter grain.

4. A motor as claimed in claim 2, wherein the casing is made from a material selected from the group consisting of aluminum, steel, and magnesium.

5. A motor as claimed in claim 1, wherein the second ignition grain means is for igniting the second pulse grain with hot gases.

6. A motor as claimed in claim 1, which includes a grain support supporting the second pulse grain, the second ignition grain means being arranged for melting the grain support when the second pulse grain is ignited.

7. A motor as claimed in claim 1, in which the igniter means includes at least one first igniter pressure port means connected to the first igniter for detecting a pressure thereof, and at least one second igniter pressure port means connected to the second igniter for detecting a pressure thereof.

8. A motor as claimed in claim 1, wherein the first and second pulse grains each have a surface disposed therein which cooperatively define an ignition cavity.

9. A motor as claimed in claim 8, in which (a) the first grain has a central portion projecting toward the fore portion of the pressure vessel; and (b) the second grain has a central recess accommodating the cen-

tral portion of the first grain.

10. A motor as claimed in claim 9, in which the igniter means comprises a first pulse igniter disposed in a portion of the ignition cavity; and a second pulse igniter disposed proximate the second pulse grain in a fore direction of the recess.

11. A motor as claimed in claim 4, wherein said casing is made from aluminium.

Patentansprüche

1. Zweiphasiger Feststoffmotor (10) umfassend:
(a) ein Druckgefäß (12) mit einer hinteren Öffnung zum Freisetzen von Treibstoffmaterial daraus, dadurch gekennzeichnet, daß der Motor umfaßt:

    (b) einen ersten Schubtreibsatz (24), der in einem hinteren Bereich des Druckgefäßes angeordnet ist;

    (c) einen zweiten Schubtreibsatz (26), der in einem vorderen Bereich des Druckgefäßes angeordnet ist; und

    (d) Zündmittel (36), die im vorderen Bereich des Druckgefäßes zum selektiven Zünden des ersten Schubtreibsatzes (24) und des zweiten Schubtreibsatzes (26) angeordnet sind, wobei die Zündmittel einen ersten Schubzünder, der nahe dem ersten Schubtreibsatz (24) angeordnet ist, und einen zweiten Schubzünder, der nahe dem zweiten Schubtreibsatz (26) angeordnet ist, umfassen, wobei der zweite Schubzünder einen Zünderverschluß (42), der ringförmige Oberflächen darin angeordnet aufweist, die eine Zündkammer (54) festlegen, und ein zweites Zündtreibsatzmittel (56) zur Zündung des zweiten Schubtreibsatzes (26) umfaßt, wobei der Zünderverschluß (42) zumindest einen Düsenauslaß (58) umfaßt, der einen Pfad von der Zündkammer (54) zum zweiten Schubtreibsatz (26) schafft.

2. Motor nach Anspruch 1, bei welchem der erste Schubzünder ein Gehäuse und ein erstes Zündtreibsatzmittel zum Zünden des ersten Schubtreibsatzes und zum Verbrennen des Gehäuses umfaßt.

3. Motor nach Anspruch 2, bei welchem das erste Zündtreibsatzmittel zumindest einen von (a) zumindest einem primären ersten Zündtreibsatz und einen ersten Zündtreibsatzverstärker umfaßt; und (b) zumindest einen Zündtreibsatz, zumindest eine Zündtablette und eine Abschirmung, welche die Zündtablette und den Zündtreibsatz trennt, umfaßt.

4. Motor nach Anspruch 2, wobei das Gehäuse aus einem Material hergestellt ist, welches aus der Gruppe, die Aluminium, Stahl und Magnesium umfaßt, ausgewählt wird.

5. Motor nach Anspruch 1, wobei das zweite Zündtreibsatzmittel für das Zünden des zweiten Schubtreibsatzes mittels heißer Gase vorgesehen ist.

6. Motor nach Anspruch 1, welcher eine Treibsatzhalterung umfaßt, die den zweiten Schubtreibsatz hält, wobei das zweite Zündtreibsatzmittel so angeordnet ist, daß es die Treibsatzhalterung schmilzt, wenn der zweite Schubtreibsatz gezündet wird.

7. Motor nach Anspruch 1, bei welchem das Zündermittel zumindest einen ersten Zünderdruckauslaß, der mit einem ersten Zünder zum Aufnehmen eines Drucks davon verbunden ist, und zumindest einen zweiten Zünderdruckauslaß, der mit einem ersten Zünder zum Aufnehmen eines Drucks davon verbunden ist, umfaßt.

8. Motor nach Anspruch 1, wobei sowohl der erste als auch der zweite Schubtreibsatz eine Oberfläche aufweisen, die jeweils im Inneren angeordnet ist und die gemeinsam einen Zündhohlraum festlegen.

9. Motor nach Anspruch 8, in welchem (a) der erste Treibsatz einen mittigen Bereich aufweist, der in Richtung des vorderen Abschnitts des Druckgefäßes vorragt, und (b) der zweite Treibsatz eine mittige Vertiefung aufweist, die den mittigen Bereich des ersten Treibsatzes aufnimmt.

10. Motor nach Anspruch 9, in welchem das Zündermittel einen ersten Schubzünder, der in einem Bereich des Zündhohlraums angeordnet ist; und einen zweiten Schubzünder, der nahe des zweiten Schubtreibsatzes in einer vorderen Richtung der Vertiefung angeordnet ist, aufweist.

11. Motor nach Anspruch 4, wobei das Gehäuse aus Aluminium hergestellt wird.

Revendications

1. Moteur à double phase à propulseur solide (10) comprenant :

    (a) un récipient de pression (12) présentant un orifice postérieur pour permettre à la matière de propulsion de s'en échapper, caractérisé en ce que ledit moteur comprend :
    (b) un premier pain de poudre (24) placé dans une partie postérieure dudit récipient de pression,

(c) un second pain de poudre (26) placé dans une partie antérieure dudit récipient de pression, et

(d) un moyen d'allumage (36) placé dans la partie antérieure du récipient de pression pour allumer au choix le pain de poudre de première impulsion (24) ou le pain de poudre de seconde impulsion (26), ledit moyen d'allumage comprenant un allumeur de première impulsion placé au voisinage du pain de poudre de première impulsion (24) et un allumeur de seconde impulsion placé à proximité du pain de poudre de seconde impulsion (26), l'allumeur de seconde impulsion comportant un couvercle d'allumeur (42) possédant des faces internes toroïdales qui délimitent une chambre d'allumage (54) et un second moyen d'allumage de pain de poudre (56) servant à allumer le pain de poudre de seconde impulsion (26), le couvercle d'allumeur (42) comprenant au moins un accès de tuyère (58) constituant un chemin de la chambre d'allumage (54) au pain de poudre de seconde impulsion (26).

2. Moteur selon la revendication 1, dans lequel l'allumeur de première impulsion comporte un boîtier, et un moyen de pain de poudre de poudre de premier allumage servant à allumer le pain de poudre de première impulsion et à brûler le boîtier.

3. Moteur selon la revendication 2, dans lequel ledit moyen de pain de poudre de premier allumage comprend au moins l'un des éléments suivants :

(a) au moins un pain de poudre de premier allumage primaire, et un pain de poudre de premier allumage d'appoint,

(b) au moins un pain de poudre d'allumage, au moins une pastille d'allumage, et un écran séparant ladite pastille d'allumage du pain de poudre d'allumage.

4. Moteur selon la revendication 2, dans lequel le boîtier est fait d'une matière choisie dans le groupe constitué de l'aluminium, de l'acier et du magnésium.

5. Moteur selon la revendication 1, dans lequel le second moyen de pain de poudre d'allumage sert à allumer le pain de poudre de deuxième impulsion au moyen de gaz chauds.

6. Moteur selon la revendication 1, comprenant un support de pain de poudre pour soutenir le pain de poudre de deuxième impulsion, le moyen de poudre de second allumage étant conçu pour faire fondre le support de pain de poudre quand on allume le pain de poudre de deuxième impulsion.

7. Moteur selon la revendication 1, dans lequel le moyen d'allumage comprend au moins un moyen d'accès de pression de premier allumage relié au premier allumeur afin de mesurer sa pression, et au moins un moyen d'accès de pression de second allumage relié au second allumeur pour mesurer sa pression.

8. Moteur selon la revendication 1, dans lequel les pains de poudre de première et seconde impulsions possèdent chacun une surface prévue de manière à ce que ces surfaces délimitent ensemble une cavité d'allumage.

9. Moteur selon la revendication 8, dans lequel

(a) le premier pain de poudre présente une partie centrale faisant saillie vers la partie antérieure du récipient de pression, et

(b) le second pain de poudre présente un évidement central destinée à loger la partie centrale du premier pain de poudre.

10. Moteur selon la revendication 9, dans lequel le moyen d'allumeur comprend un allumeur de première impulsion placé dans une partie de ladite cavité d'allumage, et un allumeur de seconde impulsion placé dans ledit évidement à l'avant et à proximité du pain de poudre de seconde impulsion.

11. Moteur selon la revendication 4, dans lequel ledit boîtier est en aluminium.

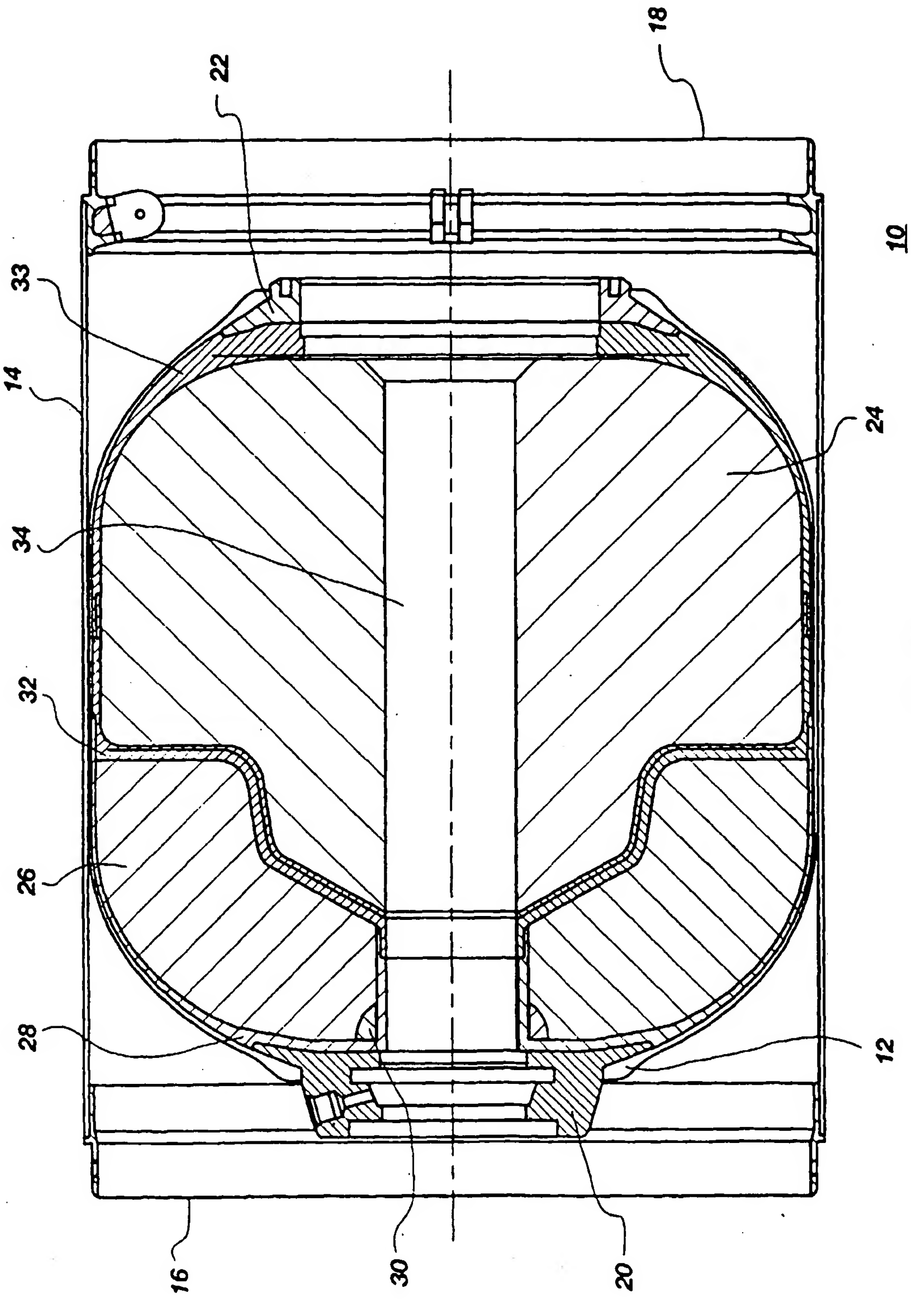

Fig. 1

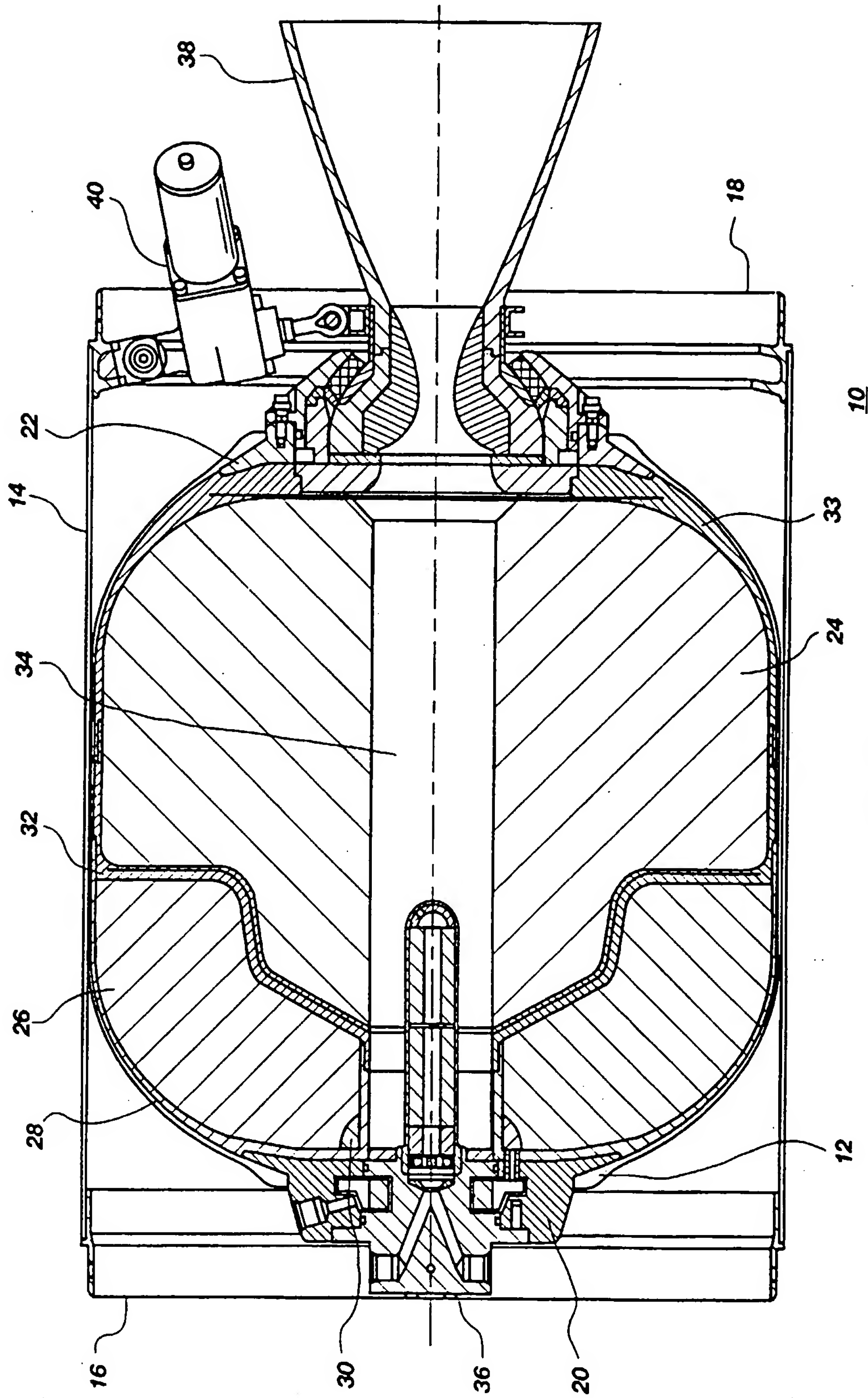

Fig. 2

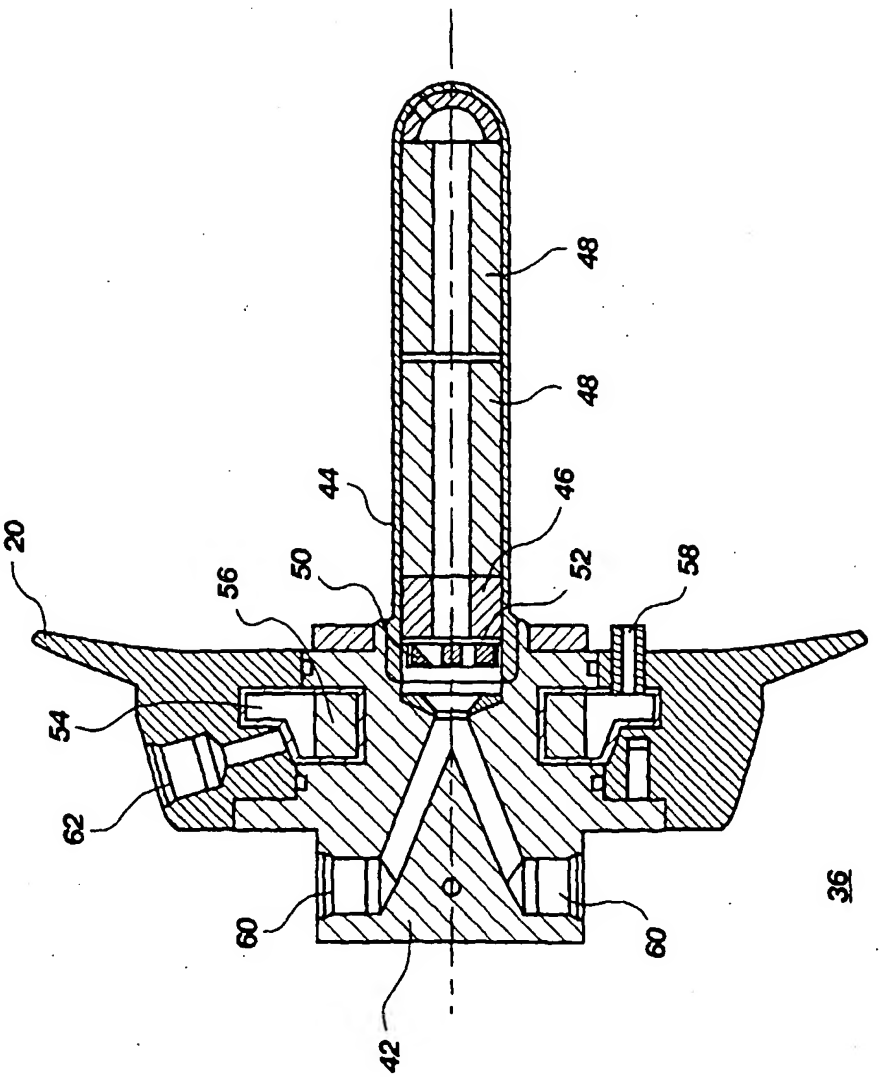

Fig. 3